

TROPHIC STRUCTURE OF SOME COMMUNITIES OF FYNBOS BIRDS*

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ABSTRACT

Comparisons are made between aspects of the trophic structure of avian communities (at the alpha-diversity level) of the four major vegetation types of the fynbos biome in the south-western Cape, in order to point up some of the rôles that birds can potentially play in ecological processes in the fynbos ecosystem. More particularly, the report deals with selected features of plants as well as birds, in an attempt to evaluate the probable importance of birds as agents for either pollination or seed dispersal in fynbos vegetation.

Avian standing crop biomass and energy requirements are about five times higher in Coastal Renosterveld and Strandveld than in either Coastal or Mountain Fynbos, reflecting a major difference in the density of birds. Bird density is not unusually low in fynbos generally, in relation to some other terrestrial biome types in southern Africa, and the avifauna can be characterized as one of relatively small-bodied birds. Primary consumers account for some 50-70 % of the avian-based energy transfer in fynbos generally, and secondary and tertiary consumers are almost exclusively insectivorous. The primary consumer component is greatest in Strandveld and Coastal Renosterveld. In Mountain Fynbos the avian primary consumer component approaches or slightly exceeds 70 % apparently only in old vegetation; insectivores being relatively more prominent in younger, regenerating stands of vegetation. The production of avian food resources is allocated differently in the four main fynbos vegetation types and, concomitantly, there are trends for disproportionate increases in the relative biomass of frugivores, granivores and, to a lesser extent, folivores with an increase in total avian biomass. The nectar-eating class, however, decreases and the proportion of the insect-eating class is similar across such an arrangement. More particularly, seeds and foliage apparently are more abundantly available to birds in Strandveld and Coastal Renosterveld than in Coastal and Mountain Fynbos, and fleshy fruits are relatively abundant only in Strandveld.

Broadly speaking, seasonal cycles of vegetative growth and flowering are opposite in Strandveld and Coastal Renosterveld on the one hand, and Coastal Fynbos and low-altitude Mountain Fynbos on the other. These differences are matched very roughly by changes in the seasonal composition of the avifaunas, particularly the nectarivorous species. However, the changes in avian species composition and abundance appear to be relatively small in Strandveld and Coastal Renosterveld communities. In essence, this means that Coastal and Mountain Fynbos avian communities are more dynamic, reflecting the birds' movements in tracking spatially and temporarily fluctuating resources. The actual movements made by the birds are not well understood, and their study is needed urgently to provide the knowledge essential for proper conservation of fynbos in the south-western Cape. This applies particularly to the nectarivorous birds which apparently are important pollinators of many fynbos plants.

* Accepted for publication 10th March, 1982.

UITTREKSEL

DIE VOEDINGSAMESTELLING VAN SOMMIGE GEMEENSAPPE FYNBOS VOËLS

Vergelykings word getref tussen aspekte van voedingsamestelling van voëlgemeenskappe (by die alpha-verskeidenheid vlak) van die vier hoof-plantegroei tipes van die fynbos bloom in die suid-westelike Kaap, sodat sommige van die rolle wat voëls moontlik kan speel in die ekologiese prosesse in die fynbos ekosisteem bepaal kan word. Daar word veral gelet op geselekteerde eienskappe van plante en voëls, in 'n poging om bestuiwings- of saadverspreidingsagente in fynbos te bepaal.

Die biomassa van die voëls en hulle energiebehoefte is sowat vyf keer hoër in Kusrenosterveld en Strandveld as in beide Kus- en Bergfynbos wat op 'n groot verskil in voëlbevolking dui. Die digtheid van voëls is nie buitengewoon laag in fynbos in vergelyking met ander bloom tipes in suidelike Afrika nie en die voëlbevolking word gekenmerk deur relatief klein voëltjies. Primêre verbruikers is sowat 50 tot 70 % van die voël-energieoordrag in fynbos en sekondêre en tersiêre verbruikers is byna uitsluitlik insekvereters.

Die primêre verbruiker-komponent is die grootste in Strandveld en Kusrenosterveld. In Bergfynbos kom die primêre voël verbruiker alleen in ou fynbos naby 70 %. Insekvereters is relatief meer prominent in jonger, herstellende stande plantegroei. Die produksie van voël voedselbronne is verskillend in die vier hoof fynbos plantegroei-tipes en terselfdertyd is daar 'n neiging vir 'n oneweredige vermeerdering in die relatiewe biomassa van vrugte-, graan- en, tot 'n mindere mate, blaarvreters met 'n toename in die totale voëlbiomassa. Die nektaretende klas verminder en die verhouding van inseketers is insgelyk dwars met so 'n reëling. Dit is veral sade en blare wat meer gereedlik beskikbaar is vir voëls in die Strandveld en Kusrenosterveld as in die Kus- en Bergfynbos en vlesige vrugte is slegs in die Strandveld relatief volop.

In die breë gesien, is die seisoens-groei siklusse en blomtye teenoorgesteld in die Strandveld en Kusrenosterveld aan die een kant en die Kusfynbos en lae hoogte Bergfynbos aan die ander kant. Hierdie verskil word rofweg gevolg deur die veranderinge in seisoens-samestelling van die voëlbevolking, veral die nektareters. Tog blyk veranderinge in die samestelling van die voëlbevolking en voorkoms relatief klein in die Strandveld- en Kusrenosterveld-gemeenskappe. Dit beteken in werklikheid dat Kus- en Bergfynbos-voëlgemeenskappe meer dinamies is omdat hulle bewegings tydelik fluktuierende bronne volg. Die werklike beweging van voëls word nog nie goed verstaan nie en verdere studie is noodsaaklik terwille van die behoorlike bewaring van die fynbos van die suidwes-Kaap. Dit is veral van toepassing op die nektareters wat blykbaar belangrike bestuiwers van baie fynbos plante is.

INTRODUCTION

Each of the four major vegetation types of the fynbos biome in the south-western Cape, South Africa, supports a distinct avifauna, with avian species richness in communities of Coastal Fynbos, Coastal Renosterveld and Strandveld being about double that in Mountain Fynbos (Siegfried and Crowe, 1982). Here I report on a preliminary and provisional comparison of aspects of the trophic organizations of these avifaunas, in order to point up some of the rôles that the birds potentially can play in ecological processes in the fynbos ecosystem. More particularly, I report on selected features of plants as well as birds, in an attempt to evaluate the probable importance of birds as agents for either pollination or seed dispersal in fynbos vegetation.

STUDY AREA AND METHODS

Detailed descriptions of 11 study sites (Appendix 1) representative of major vegetation types in the fynbos biome, and the methods used in surveying birds and plants in these vegetation types, are given in Siegfried and Crowe (1982). Phenological data on flowering, fruiting and vegetative growth of 10 individually-marked plants of each of the most prominent (conspicuous and/or abundant) species, in four segments along two transects, were recorded each month during at least 12 months in each of the vegetation types. The size, form and colour of the species' seeds, fruits and flowers were recorded at each of the 11 study sites. An additional study site comprising 50 ha of mature Coastal Fynbos near Hopefield (S 33° 3' E 18° 22') was censused regularly for birds, but the vegetation was not studied.

RESULTS AND DISCUSSION

Avian biomass and consumers

Avian standing crop biomass in Coastal Renosterveld and Strandveld is about five times higher than that in either Coastal or Mountain Fynbos (Table 1). The relatively high biomass in Coastal Renosterveld and Strandveld is not due to a disproportionate number of heavier species, but it is rather a reflection of denser populations of birds (Fig. 1, Table 2). Avian standing crop biomass in Coastal and Mountain Fynbos is considerably lower than that in savanna vegetation (Table 1). However, bird density is not unusually low in fynbos in relation to some other terrestrial biome types in southern Africa (Table 2). Hence, it is likely that the fynbos avifauna can be characterized as one of relatively small-bodied birds.

TABLE 1.

Bird biomass (kg/100 ha) and energy requirement (kcal/m²/y⁻¹) in savanna and fynbos vegetation in southern Africa. First approximation annual energy requirement was calculated following Tarboton (1980) and using the Lasiewski-Dawson (1967) equation. (Comparable figures for other terrestrial biome types in southern Africa are not yet available.)

Vegetation	Biomass	Energy	Source
<i>Acacia</i> Woodland, Transvaal	84,6	17,5	Tarboton (1980)
<i>Burkea</i> Woodland, Transvaal	40,7	7,5	Tarboton (1980)
Strandveld	42,6–45,6	9,6–11,2	This study
Coastal Renosterveld	45,9	10,9	This study
Coastal Fynbos	7,9–8,3	1,9–2,3	This study
Mountain Fynbos	3,1–14,1	1,9–2,7	This study

The avian communities of Strandveld and Coastal Renosterveld vegetation have energy requirements similar to that of a *Burkea* savanna avifauna (Table 1). Primary consumers account for some 50–70 % of the avian-based energy transfer in fynbos communities, and secondary and tertiary consumers are almost exclusively insectivores (Table 3). Primary consumers ap-

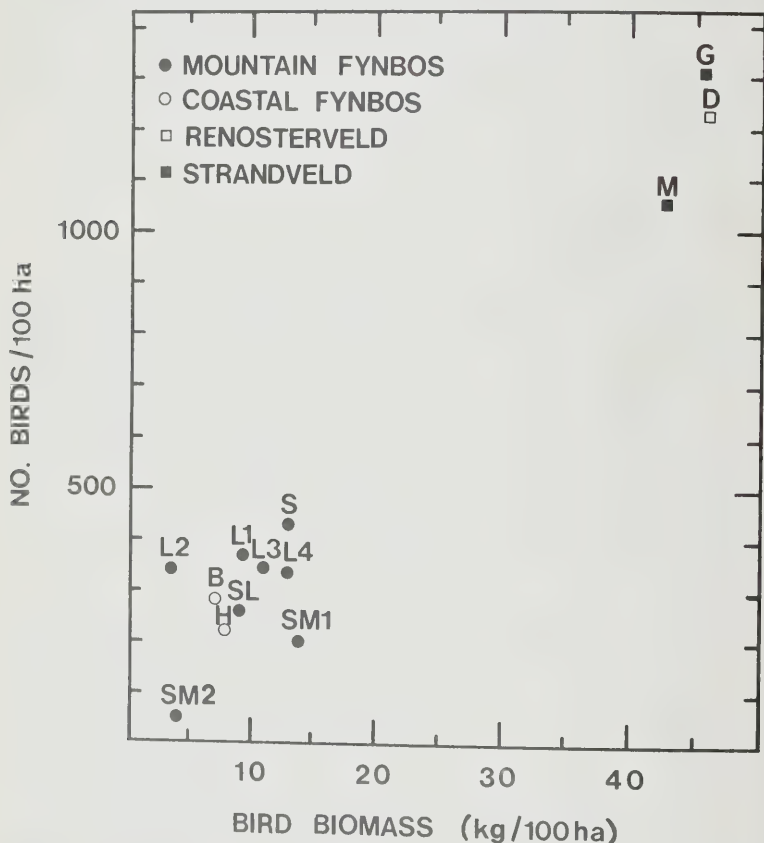


FIG. 1.

Relationship between density and standing crop biomass of birds in Mountain Fynbos (SL Sir Lowry's Pass, S Swartboschkloof, SM Silvermine, L Lebanon), Coastal Fynbos (B Barhuis, H Hopefield), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on monthly mean numbers of birds censused during a full year.

parently rank lower in *Acacia* and *Burkea* savanna avifaunas; and, in the *Acacia* community ($2.3 \times$ the annual energy requirements of the *Burkea* community) they provide slightly more than 50 % of the energy transfer, whereas in *Burkea* it is the secondary and tertiary components that do so (Tarboton, 1980). Accepting that the data sets are at best first approximations, this trend is paralleled in fynbos in that the primary consumer component is greatest in Strandveld and Coastal Renosterveld which, similarly to the *Acacia* community, occur on soils relatively rich in plant nutrients (Kruger, 1979) and whose primary production is suspected to be greater than in Mountain or Coastal Fynbos. In Mountain Fynbos, at least, the primary consumer component approaches or slightly exceeds 70 %, in the avian-based energy transfer, apparently only in old vegetation; insectivores being relatively more prominent in younger, regenerating stands of vegetation.

There is a paucity of information on standing crop biomass of plant communities in the different fynbos vegetation types, and virtually nothing is

TABLE 2.
Bird density in vegetation types in southern Africa

Vegetation	No. birds/ 100 ha	Source
Valley Bushveld, eastern Cape	1 235-3 000	Winterbottom (1972)
Thorn Bushveld, eastern Cape	204	Skead (1946a)
Karroid Broken Veld, Klaarstroom	72-235	Winterbottom (1972)
Karroid Broken Veld, Robertson	764	Winterbottom (1972)
Central Upper Karoo	486	Winterbottom (1972)
Karoo, South West Africa	348	Winterbottom (1972)
Floodplain Grassland, Zambia	1 108	Winterbottom (1972)
Floodplain Grassland, Botswana	1 760	
<i>Themeda</i> Grassveld, eastern Cape	58-272	Skead (1946b)
Southern Tall Grassveld, Transkei	353	Winterbottom (1947)
<i>Cynopogon/Themeda</i> Grassveld, Lesotho	299	Winterbottom (1972)
Mopane Woodland, Zambezi Valley	1 400	Winterbottom (1956)
<i>Brachystegia</i> Woodland, Zambia	620	Winterbottom (1972)
<i>Acacia</i> Woodland, Transvaal	925-1 600	Tarboton (1980)
<i>Burkea</i> Woodland, Transvaal	399-900	Tarboton (1980)
Strandveld	1 034-1 273	This study
Coastal Renosterveld	1 230	This study
Coastal Fynbos	236-291	This study
Mountain Fynbos	200-431	This study
Fynbos	380-700	Winterbottom (1978)

TABLE 3.
Relative energy requirements of consumer classes of avian communities in fynbos vegetation in the south-western Cape. All figures are percentages

Vegetation type							
Secondary and tertiary consumers	Insectivores	28-34	33	38-52	26-56	1	1
	Others	1	1	1	1	2-62	1
Primary consumers	Nectarivores	5-6	6	4-7	1	24-25	6-8
	Frugivores	24-25	3	2-7	1	28-36	2
	Granivores	28-36	56	42-45	5-72	1	1
	Folivores	6-8	2	1	1		

known about their net primary production. Nevertheless, the large difference in avian biomass between Strandveld and Coastal Renosterveld on the one hand and fynbos *sensu stricto* on the other, implies that only a relatively small fraction of the primary production in Coastal and Mountain Fynbos passes to birds and/or that primary production in these vegetation types is relatively low (Fig. 2). There are also indications that production of avian,

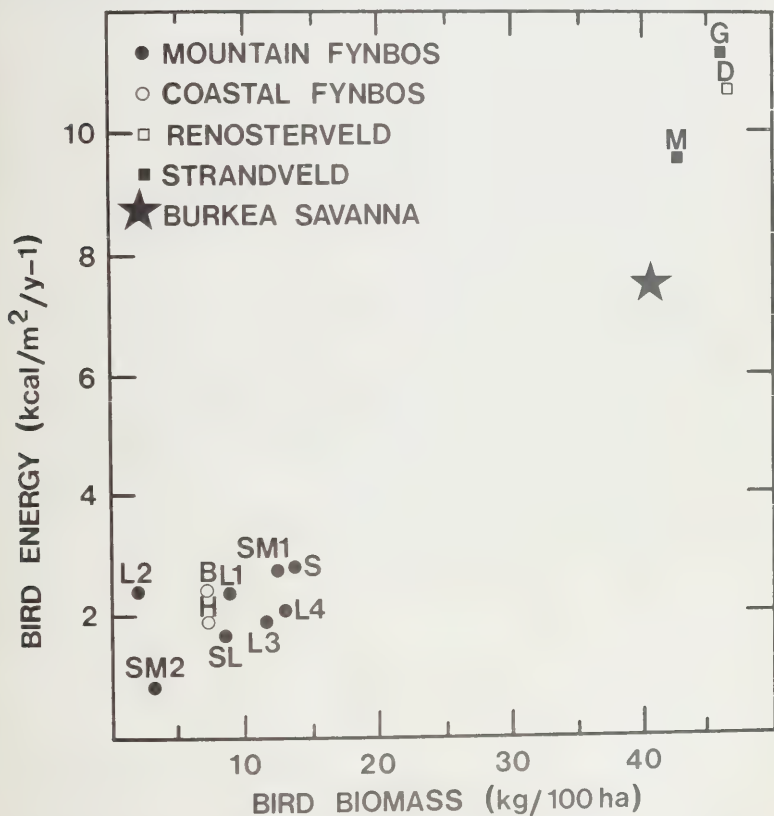


FIG. 2.

Relationship between annual energy requirements and standing crop biomass of birds in Mountain Fynbos (SL Sir Lowry's Pass, S Swartboschkloof, SM Silvermine, L Lebanon), Coastal Fynbos (B Barhuis, H Hopefield), Renosterveld (D De Gredel), Strandveld (G Geelbek, M Melkbosch) and *Burkea* savanna vegetation types. Based on monthly mean numbers of birds censused during a full year and data in Table 1.

food resources of different quality (e.g. fruits, seeds, foliage, nectar, insects, etc.) is allocated differently in the different vegetation types.

There are indications of disproportionate increases in the relative biomass of frugivores, granivores and to a much lesser extent folivores concomitant with an increase in total avian biomass, whereas the nectar-eating class decreases and the proportion of the insect-eating group is similar across a particular arrangement of vegetation types (Fig. 3). In this context, it is

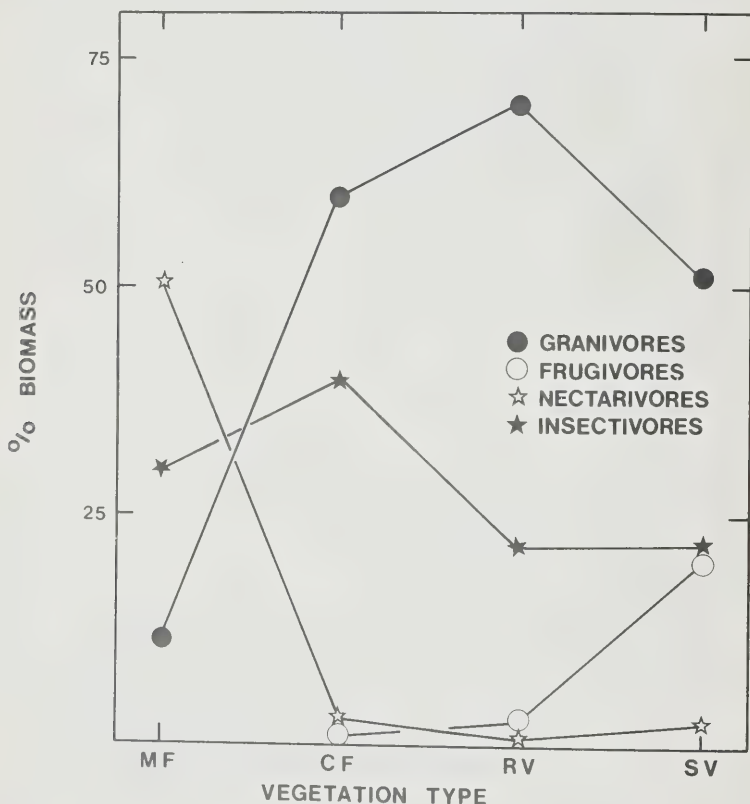


FIG. 3.
Proportionate standing crop biomass of granivorous, frugivorous, nectarivorous and insectivorous birds in Mountain Fynbos (MF), Coastal Fynbos (CF), Renosterveld (RV) and Strandveld (SV) vegetation types. Bird biomass is based on data in Appendix 2 and monthly mean numbers of birds censused during a full year.

likely that seeds and foliage are more abundantly available to birds in Strandveld and Coastal Renosterveld than in Coastal and Mountain Fynbos. Some Mountain Fynbos plant communities might produce more nectar for birds than the communities of any of the three other vegetation types, and Mountain and Coastal Fynbos tend to contain relatively high proportions of plant species which produce flowers apparently coloured so as to enhance their attractiveness to birds (Fig. 4).

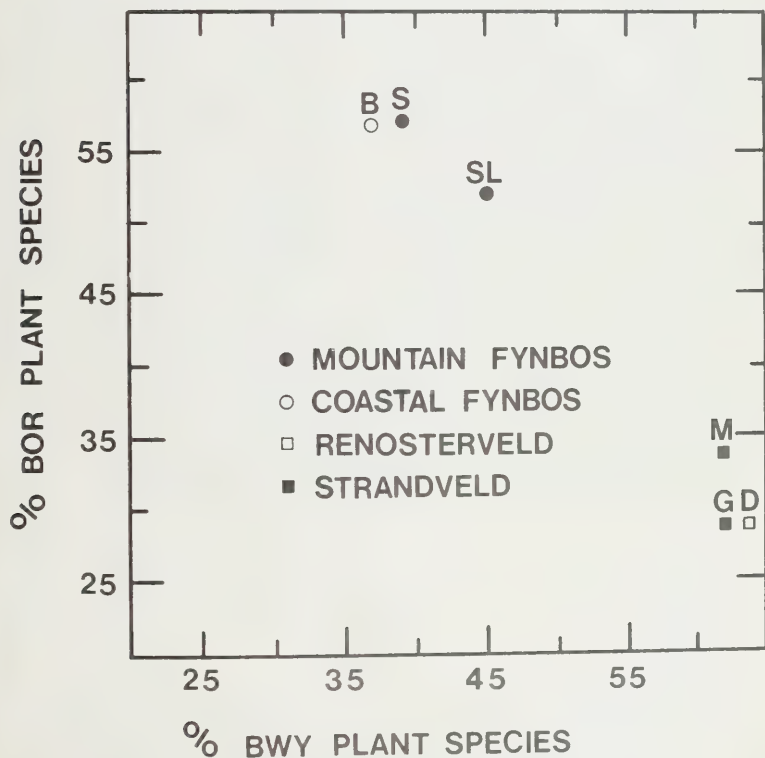


FIG. 4.

Relationship between the number of plant species having brown, orange or red (BOR) flowers and those with either blue, white or yellow (BWY) flowers in Mountain Fynbos (S Swartboschkloof, SL Sir Lowry's Pass), Coastal Fynbos (B Barhuis), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on data in Appendix 3.

There are relatively few plants producing fleshy fruits in Coastal and Mountain Fynbos. Fruits of this kind are abundant only in Strandveld vegetation (Fig. 5). Species producing fleshy fruits coloured orange/red or purple/black, colours presumably attractive to birds, are poorly represented in Mountain Fynbos communities (Table 4). Large (> 10 mm) fruits are uncommon in fynbos generally, and approximately 70 % of the plant species produce small (< 3 mm) fruits mainly as achenes (Table 4). The achenes are eaten by a variety of granivorous birds (Milewski, 1978), and at least 17 es-

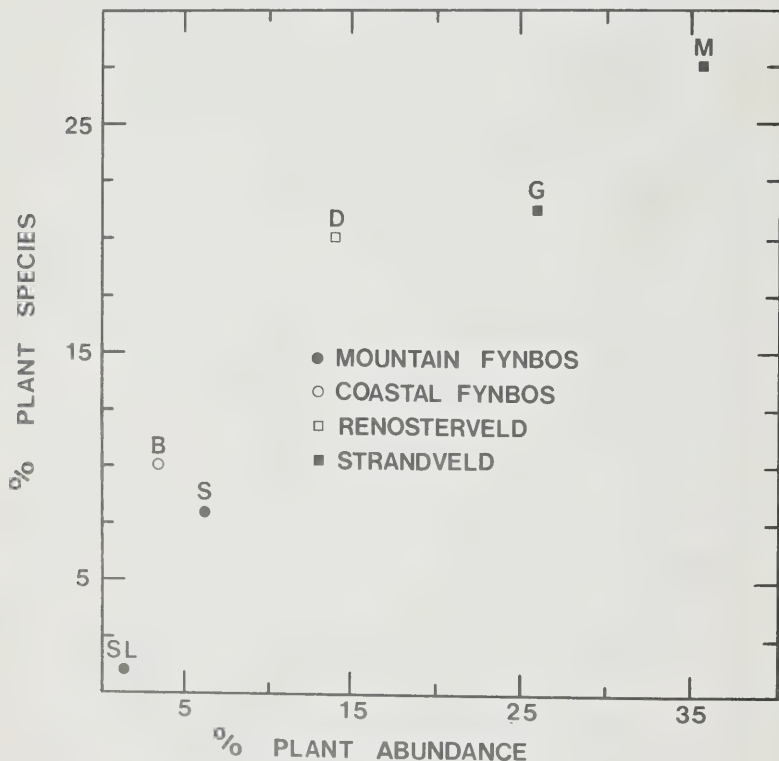


FIG. 5.

Relationship between the number of plant species producing fleshy fruits and the cover abundance (see Siegfried and Crowe, 1982) of these species in Mountain Fynbos (S Swarthboschkloof, SL Sir Lowry's Pass), Coastal Fynbos (B Barhuis), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on data in Appendix 3.

Percentage plant species with either small (< 3 mm), medium (3–10 mm) or large (> 10 mm) fruits, and percentage species with either orange/red or purple/black coloured fleshy fruits in fynbos vegetation in the south-western Cape. Fleshy fruits include either single-seeded or multi-seeded types; the remaining non-fleshy fruits include pods, nuts, achenes and capsules. Based on data in Appendix 3

TABLE 4.

Vegetation type and study area	Fruit size			Fleshy fruit colour		No. species sampled	Total No. species at site
	Small	Medium	Large	Orange/Red	Purple/Black		
Strandveld	67	29	2	13	8	60	61
Melkbosch	72	24	1	8	6	82	85
Geelbek							
Coastal Renosterveld	68	24	1	10	4	74	79
De Grendel							
Coastal Fynbos	67	33	0	9	5	21	21
Barthuis							
Mountain Fynbos							
Swartboschkloof	72	28	0	1	4	72	72
Sir Lowry's Pass	86	12	1	0	2	112	113
Silvermine, pre-fire	79	21	0	0	4	28	28
Silvermine, post-fire	74	25	0	0	4	52	53
Lebanon 1	75	23	0	0	2	52	53
Lebanon 2	81	14	0	0	2	41	43
Lebanon 3	70	29	0	0	4	69	70
Lebanon 4	75	24	0	0	3	66	67

Relative bird species richness (numbers of species) in consumer classes in fynbos vegetation in the south-western Cape. All figures are percentages, except those for species totals. Figures in parentheses indicate number of study sites in each vegetation type (see Siegfried and Crowe, 1982 for further details, including species lists)

TABLE 5.

Vegetation type	Insectivores	Granivores	Nectarivores	Others	Total No. species
Strandveld (2)	46-57	29-38	6- 8	7- 8	35-39
Coastal Renosterveld (1) ...	38	41	9	12	34
Coastal Fynbos (2)	48-51	37-40	4- 6	3-11	27-35
Mountain Fynbos (8)	30-55	20-44	12-27	0-10	8-23

entially granivorous species occur regularly in fynbos. *Acacia* and *Burkea* savanna woodland in the Transvaal support similar numbers of granivorous species (Tarboton, 1980). Thus, Winterbottom's (1968a) suggestion that avian species richness is low in fynbos because the flora is poor in seeds suitable for, and available to, birds seems unlikely. Indeed, a relatively fine degree of resource partitioning is shown by differences in diet between six sympatric or partly sympatric *Serinus* (Fringillidae) species in Mountain Fynbos alone (Milewski, 1978).

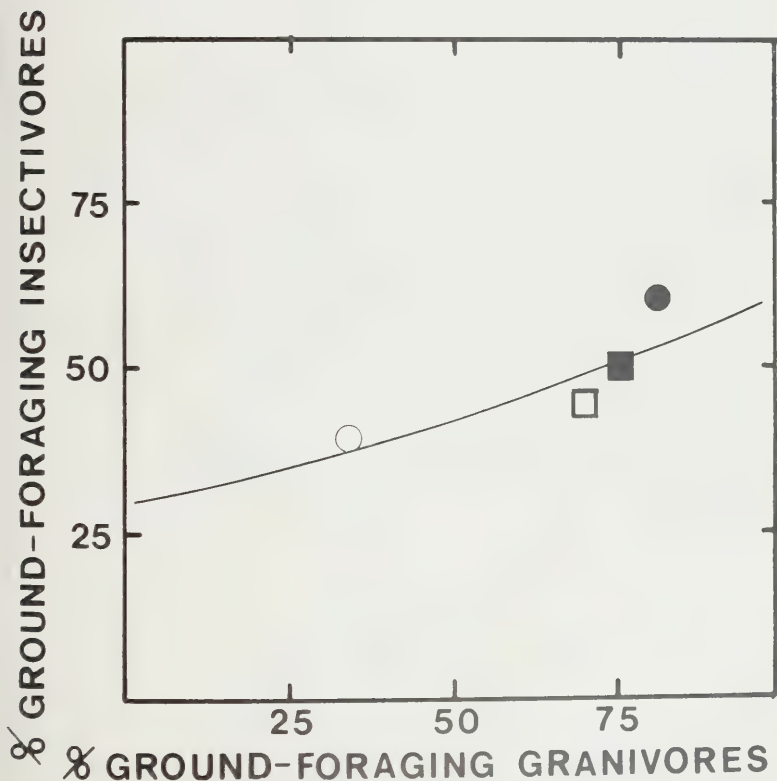


FIG. 6.

Relationship between numbers of insectivorous and granivorous bird species foraging either on ground or in vegetation

○ = Mountain Fynbos,

● = Coastal Fynbos,
■ = Strandveld

□ = Renosterveld,

The insectivores tend to contribute the highest number of species to the fynbos avifauna, closely followed by granivores (Table 5). Together, insectivorous and granivorous birds make up more than 75 % of the total species richness of the fynbos avifauna. A division of insectivorous and granivorous species into ground and above ground (but excluding aerial) foragers shows that the relative incidence of ground foragers in both classes is lowest in Mountain Fynbos and highest in Coastal Fynbos (Fig. 6). The reason for this difference is not clear, but it could be a function of a relatively high seasonal incidence of annual herbaceous plants in the lowland vegetation types.

Seasonality

Perennial plants apparently grow actively during summer in Mountain and Coastal Fynbos, whereas vegetative growth tends to peak during autumn–winter, following onset of the rainy season, in Strandveld and Coastal Renosterveld (Figs 7, 8, 9, 10). Specht (1957) considered a summer peak in growth activity to be an outstanding feature of South Australian heaths, as compared with Mediterranean garrigue and maquis, and Californian chaparral which grow in spring when ambient temperatures are less extreme.

In the relatively fruit-rich Strandveld vegetation both fruiting and flowering activities tend to peak in the austral spring (Fig. 10). A spring flowering peak occurs in comparable vegetation in West and South Australia, California, Chile and Israel (Mooney *et al.*, 1974). Flowering activity in Coastal Fynbos occurs mainly in autumn and winter (Fig. 8). Thus, very broadly speaking, seasonal cycles of vegetative growth and flowering are apparently opposite in Strandveld and Coastal Renosterveld on the one hand, and Coastal Fynbos and also low-altitude Mountain Fynbos on the other hand. The plant phenology of Mountain Fynbos is, however, much more heterogeneous than the relatively uniform patterns applicable to the other vegetation types. In Mountain Fynbos flowering activity apparently varies in relation to both altitude and age of vegetation. Generally in protea-dominated, mature vegetation at low altitudes flowering occurs mainly in winter and spring (e.g. Swartboschkloof, Fig. 7), whereas in erica-dominated, young vegetation at high altitudes flowering tends to be concentrated in summer and autumn (e.g. Sir Lowry's Pass, Fig. 7).

Species specific, age and altitudinal differences in the flowering phenology of Mountain and Coastal Fynbos communities are reflected by marked differences in the seasonal composition of their avifaunas, particularly the nectarivorous class. For instance, Cape sugarbirds *Promerops cafer* are abundant only in winter and spring at Swartboschkloof and in Coastal Fynbos when proteas tend to flower. Orangebreasted sunbirds *Nectarinia violacea* are most abundant in autumn at Sir Lowry's Pass (Figs 11–12) when ericas tend to flower.

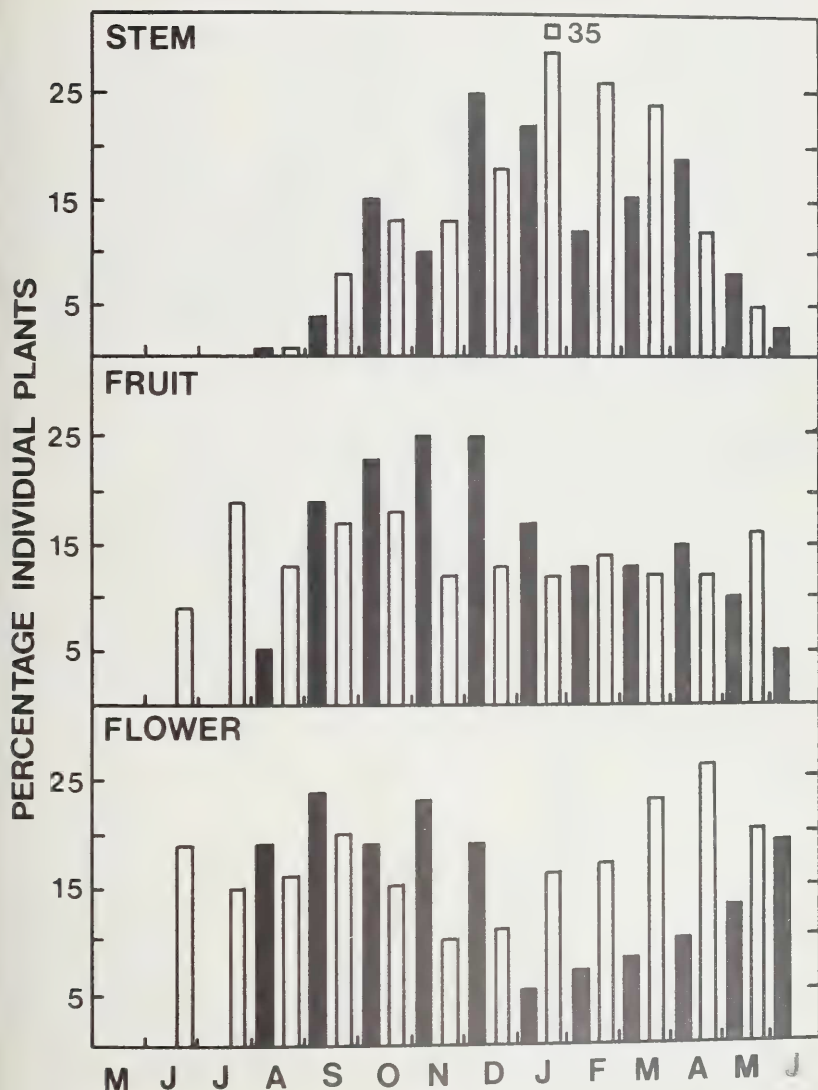


FIG. 7.

Vegetative growth, fruiting and flowering phenology in Mountain Fynbos. Shaded columns are representative of the Swartboschkloof site (404 plants of 50 species sampled August 1978–June 1979) and the unshaded columns represent Sir Lowry's Pass (543 plants of 61 species sampled June 1978–May 1979).

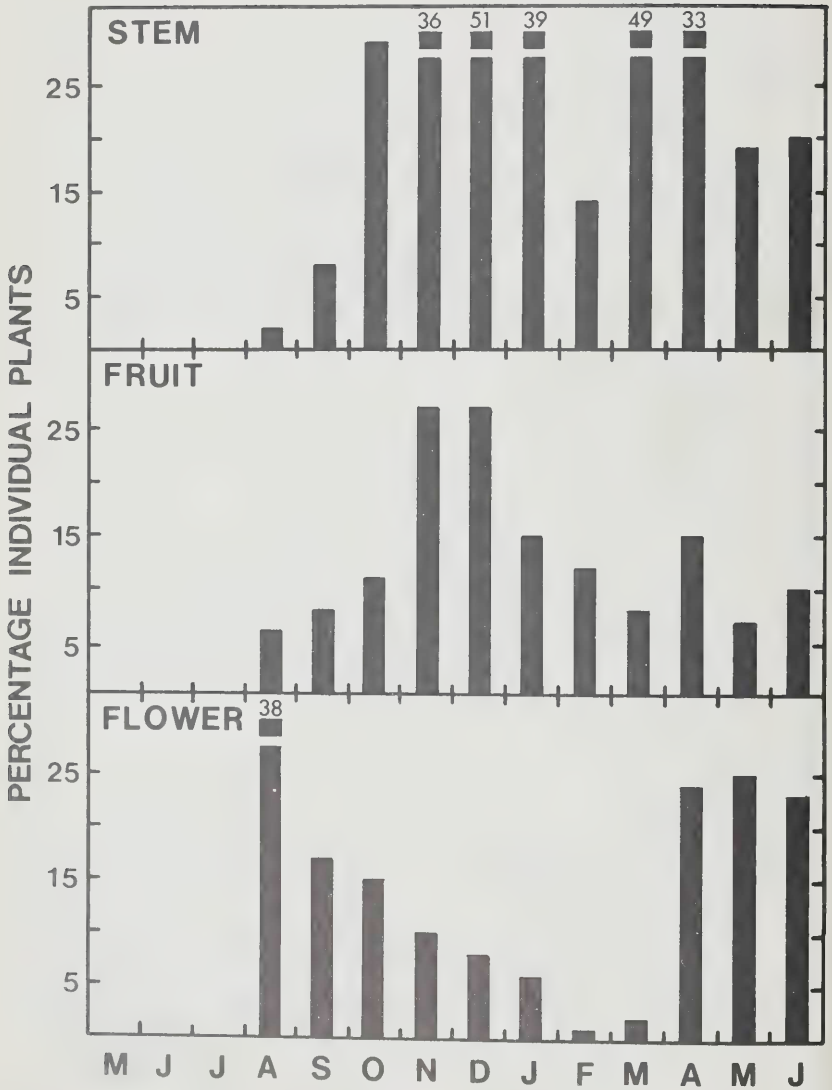


FIG. 8.

Vegetative growth, fruiting and flowering in Coastal Fynbos (Barhuis site; 235 plants of 17 species sampled August 1978–May 1979).

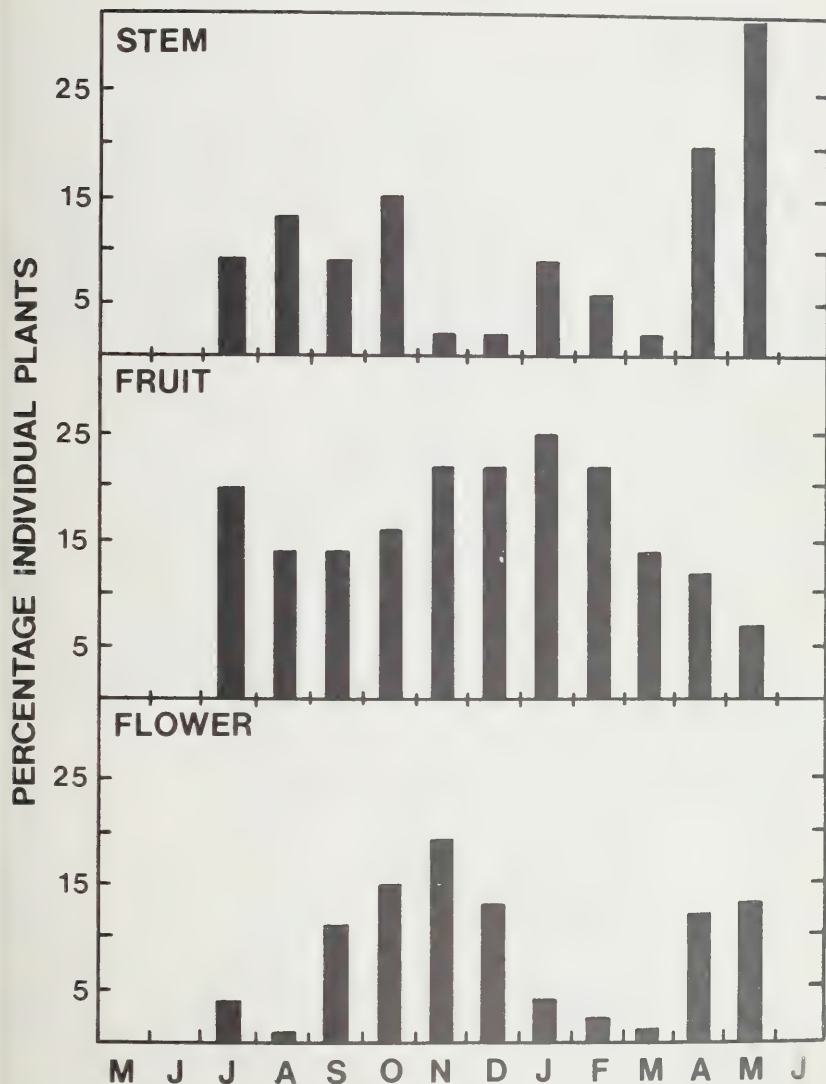


FIG. 9.

Vegetative growth, fruiting and flowering in Renosterveld (De Grendel site; 275 plants of 32 species sampled July 1978–May 1979).

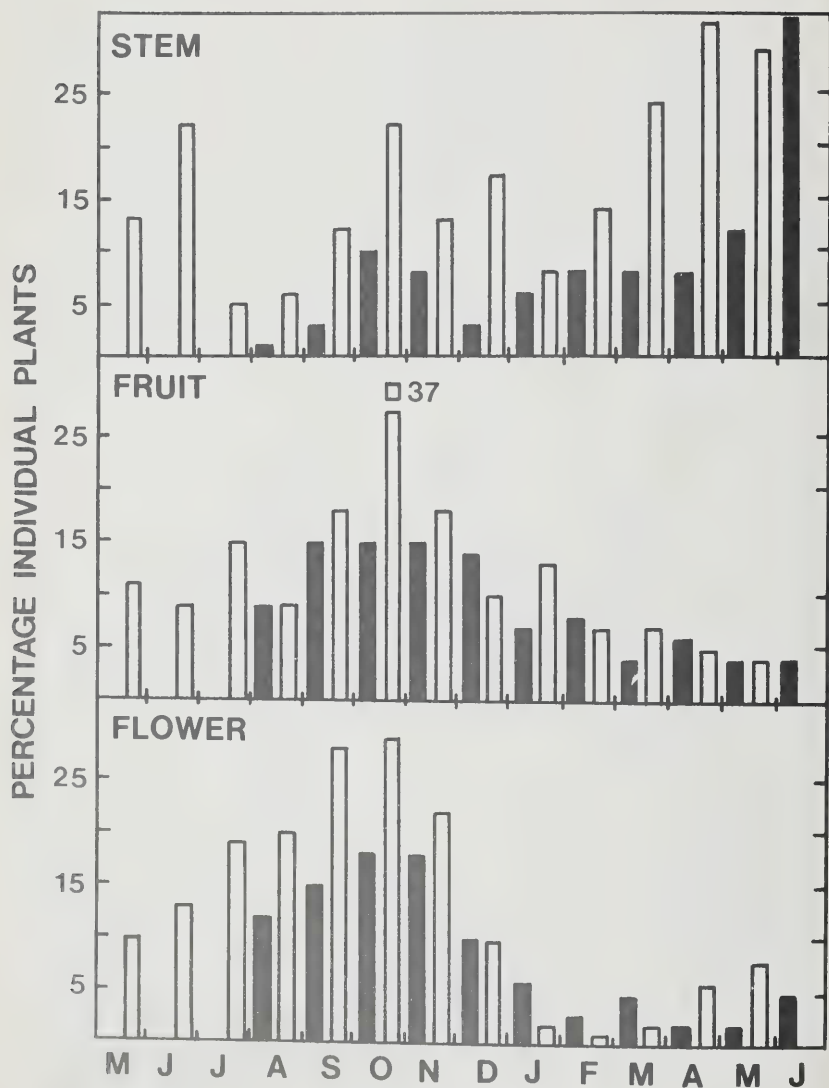


FIG. 10.

Vegetative growth, fruiting and flowering in Strandveld. Shaded columns are representative of the Geelbek site (410 plants of 44 species sampled August 1978–June 1979) and the unshaded columns represent Melkbosch (733 plants of 52 species sampled May 1978–May 1979).

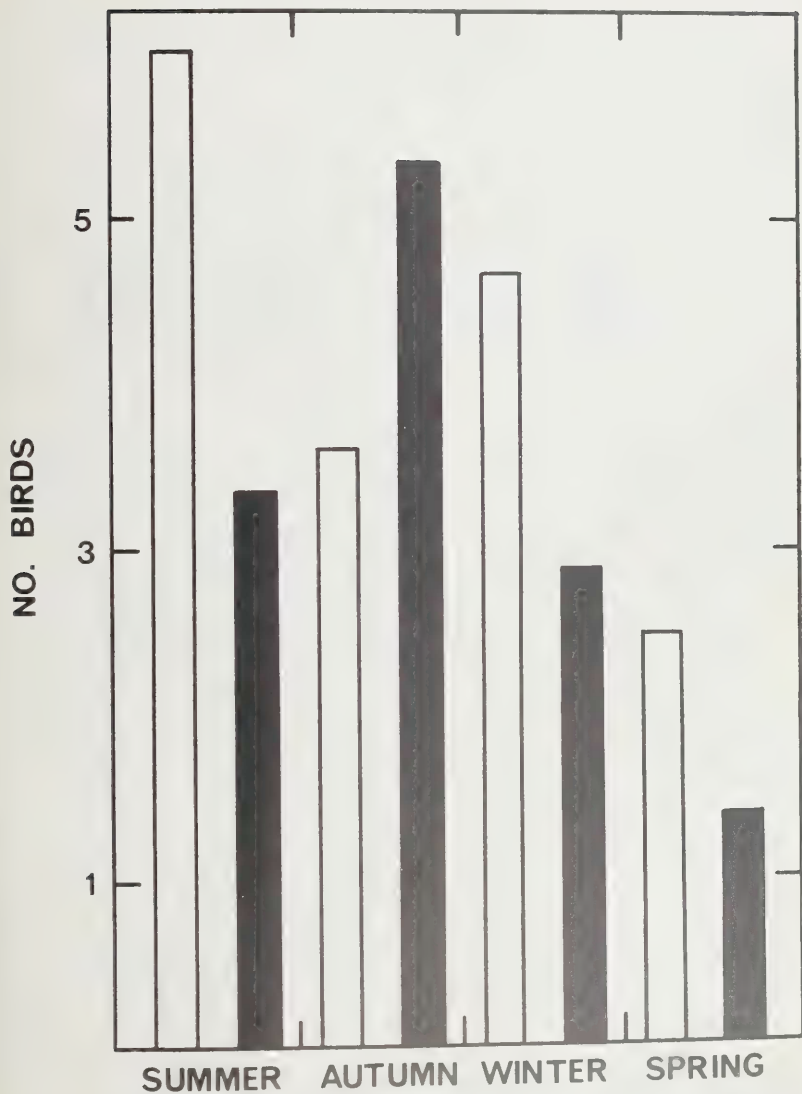


FIG. 11.

Seasonal abundance (mean number of birds in 3 ha) of orangebreasted sunbirds (shaded columns) and all other birds (unshaded columns) in a Mountain Fynbos community (Sir Lowry's Pass). Seasons are: summer (December–February), autumn (March–May), winter (June–August) and spring (September–November).

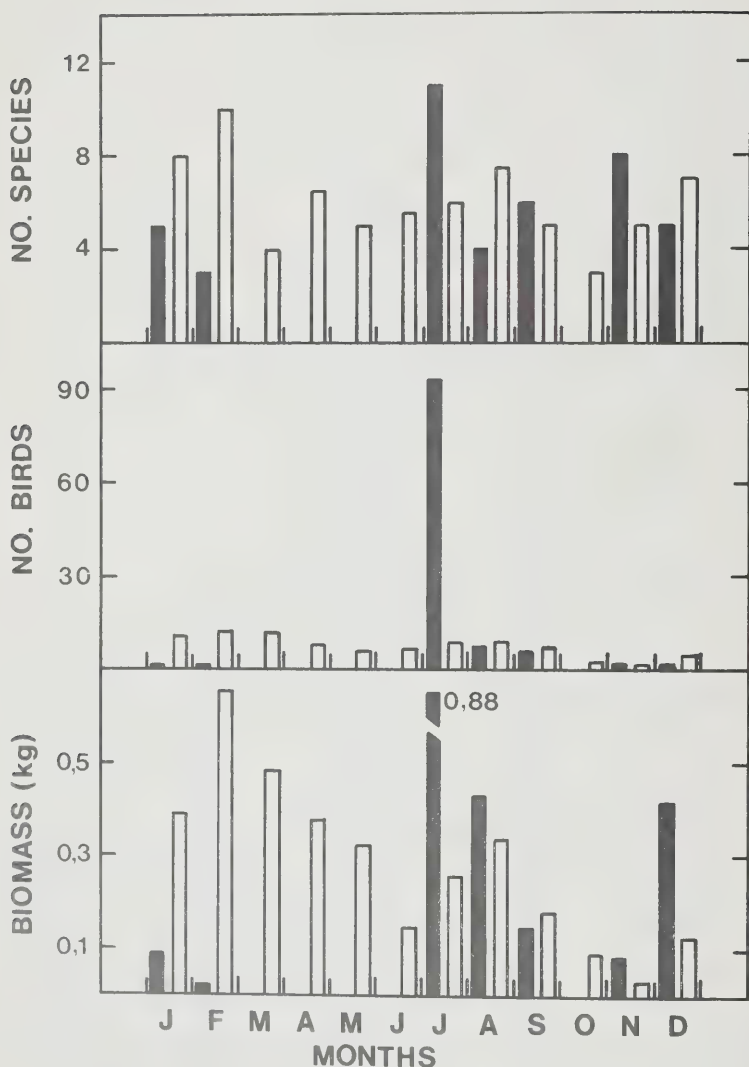


FIG. 12.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in 3-ha areas in Mountain Fynbos. Shaded columns are representative of the Swartboschkloof site (censuses were not made in March, April, May, June and October) and the unshaded columns represent Sir Lowry's Pass.

Seasonal changes in the species composition and abundance of the bird communities of the other vegetation types apparently are less marked (Figs 13–15). However, in both Coastal Renosterveld and Strandveld small increases in the number of species and larger increases in the abundance of birds tend to occur during the rainy season between April and October (Figs 14–15). These increases coincide with the main growth of annual forbs and grasses as well as the perennial plants. While part of the increase in overall avian abundance is due to recruitment of young birds following breeding which occurs mainly in late winter and early spring (Winterbottom, 1968b), it is primarily granivorous, and to a lesser extent insectivorous, birds which are involved in the population increase preceding the breeding period. Prominent among the granivorous class are the canaries *Serinus canicollis*, *S. alario* and *S. flaviventris* which form wandering, and sometimes large, flocks and commonly include soft green seeds of grasses and composites in their diets (Winterbottom, 1973; Milewski, 1978).

A winter maximum in species richness and abundance of granivorous and insectivorous birds in lowland fynbos formations has been reported also by Winterbottom (1971) who was unable to explain the phenomenon, but suggested that food was unimportant as a controlling factor. His opinion apparently was prompted by a similar suggestion made by Blondel (1969) in explaining why the winter avifauna of the Mediterranean garrigue vegetation is richer than that of summer in both species diversity and biomass. Part of the problem, however, is an artefact caused by a too rigid classification of certain avian populations as belonging to resident or sedentary species. In the fynbos, at least, it seems likely that a number of so-called residents, or sedentary birds, in fact move about extensively, regularly or irregularly, within and between major vegetation formations, in response to fluctuating food resources. It also seems likely that there are regular movements of birds from the Karoo biome into lowland fynbos whose "carrying capacity" is lowest during the dry, hot summer when many plants are either dormant or semi-dormant in Strandveld and Coastal Renosterveld and most annuals are dead in Coastal Fynbos as well.

Leaving aside the swifts (Apodidae) and swallows (Hirundinidae) which seldom are encountered foraging low over fynbos, a striking feature of all fynbos avifaunas is the virtual absence of seasonal visitors in the form of long-distance migrants (Winterbottom, 1971).

Nectarivores and frugivores

Four specialized nectarivorous bird species occur in fynbos, although each species feeds on arthropods as well. In Mountain Fynbos, the Cape sugarbird feeds mainly on nectar and arthropods associated with proteas

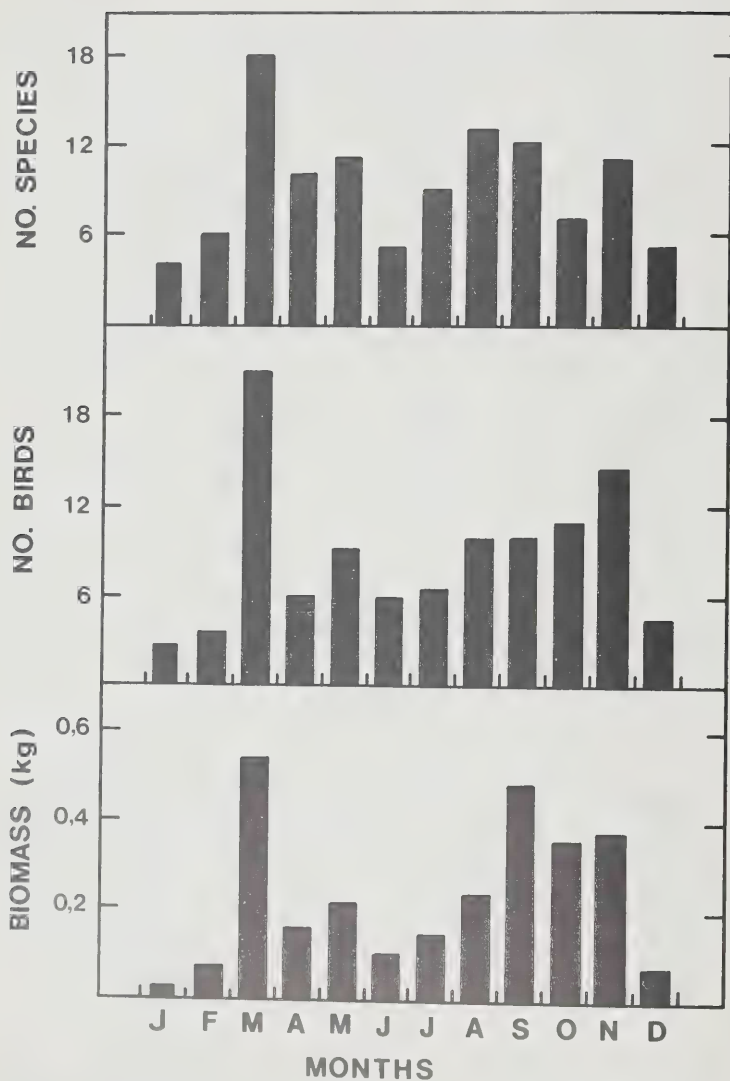


FIG. 13.

Avian species-richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in a 3-ha area in Coastal Fynbos (Barhuis site).

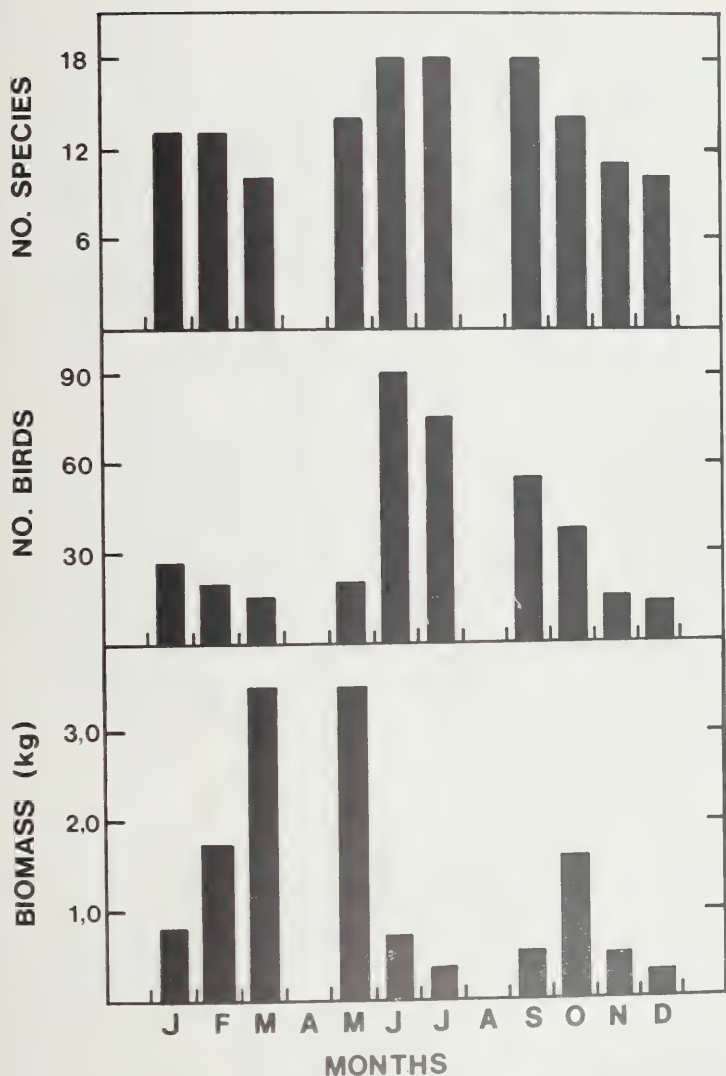


FIG. 14.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in a 3-ha area in Renosterveld (De Grendel site). Censuses were not made in April and August.

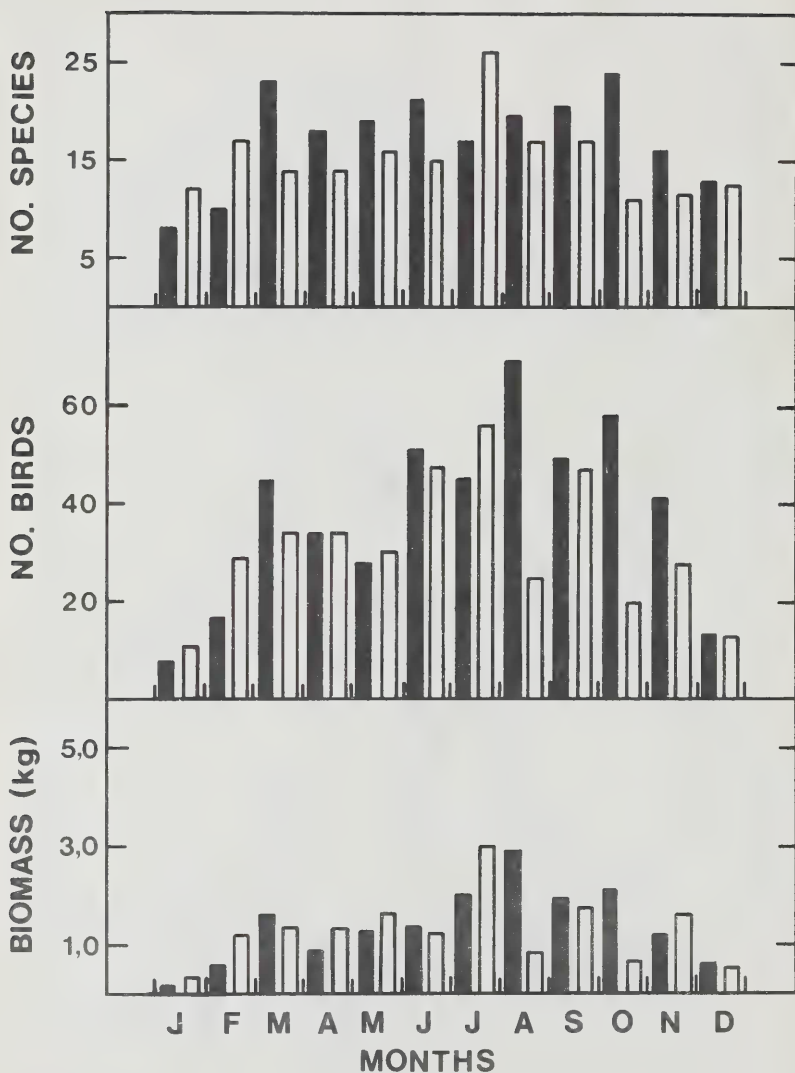


FIG. 15.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in 3-ha areas in Strandveld. Shaded columns represent the Geelbek site and the unshaded columns represent Melkbosch.

(Mostert *et al.*, 1980), whereas the orangebreasted sunbird tends to take nectar and arthropods associated with ericas (Skead, 1967). Populations of these two species are highly mobile, and they apparently move considerable distances in tracking spatially and temporarily fluctuating food resources (pers. obs.). However, whereas Cape sugarbirds occur regularly in Coastal Fynbos, and occasionally in Strandveld, as well as in Mountain Fynbos, orangebreasted sunbirds seldom are found outside the latter vegetation type (Winterbottom, 1968b; pers. obs.).

The nectar-arthropod resource base provides for an intermediately-sized, third species in the even more itinerant malachite sunbird *Nectarinia famosa* whose populations apparently move widely within and between all four vegetation types of the fynbos. This species may rely to a relatively greater extent on nectar supplies associated with ephemeral sources, such as geophytes (pers. obs.). The fourth specialist nectarivore in the fynbos is the lesser-doublecollared sunbird *Nectarinia chalybea* which approximates the orangebreasted sunbird in size. It is common in the lowland vegetation formation where it, too, has highly mobile populations (Schmidt, 1964). It occurs occasionally in Mountain Fynbos. Thus, Mountain and Coastal Fynbos each essentially has three species, of which two (*P. cafer* and *N. famosa*) are shared, whereas Strandveld and Coastal Renosterveld each essentially has only the same two species (*N. chalybea* and *N. famosa*). This difference probably mirrors the relative abundance of proteas in Coastal and Mountain Fynbos, and the relative abundance of ericas in Mountain Fynbos.

There are no fruit-eating birds permanently resident in Mountain Fynbos. The redwinged starling *Onychognathus morio* occurs itinerantly and sporadically, and it eats fruit but probably takes as much food in the form of insects and other items. Moreover, it is more properly a bird of mountainous areas, rather than Mountain Fynbos, and it undertakes long foraging journeys to forests and other sources of food. The absence of fruit-eating birds in Mountain Fynbos is a consequence of the lack of plants producing fleshy fruits; the possibility that non-avian animals are precluding fruit-eating birds can be discarded. Similarly, the low incidence of fruit-eating birds in Coastal Fynbos reflects a relative paucity of plants with fleshy fruits. This probably means that birds are unimportant as dispersers of plants, and that long-distance dispersal of plants by birds is not favoured in these two vegetation types generally. Many, if not most, of the exceptions are small trees found on the edges of streams or forest and/or are forest pioneers. However, even they produce either small, leathery fruits (e.g. *Heeria argentea*, *Rhus angustifolia*, *R. tomentosa*) or dry capsules (e.g. *Kiggelaria africana*, *Maytenus oleoides*) which dehisce to display seeds, with colourful arils, to birds. A further exception might rest in the fact that Cape sugarbirds transport and incorporate large numbers of protea seeds in their nests (Table 6.

Burger *et al.*, 1976). However, there is, as yet, no evidence for this being a significant form of seed dispersal.

TABLE 6.

Number and mass (g dry wt) of protea seeds (eight spp.) in nests (N = 25) of the Cape sugarbird

No. seeds			Mass seeds			Seeds as % of total mass of nest
$\bar{x}$	S.D.	Range	$\bar{x}$	S.D.	Range	
182	189	10-785	2,2	2,5	0,1-9,9	10,6

It is only in the strand and littoral dune communities of all three vegetation types that an enhanced incidence of plants with fleshy fruits is found. However, these seral communities are not fynbos proper but exemplify a complex interplay of fynbos and Afro-montane forest elements in the succession from pioneer littoral to scrub vegetation. Among the dominant plants in these communities, *Euclea racemosa* and *Sideroxylon inerme* produce fleshy fruits and seeds which are dispersed by fruit-eating birds, such as the Cape bulbul *Pycnonotus capensis* and the speckled coly *Colius striatus*. These plants probably have fleshy fruits because directional dispersal of their seeds by birds is the most effective way of colonizing areas which satisfy the species' specific habitat requirements in the form of mesic, sheltered sites.

Broad-leaved fruiting shrubs are common in Strandveld vegetation, normally forming relatively tall clumps interspersed with lower, more open, associations of restios (Restionaceae), succulents, herbs, dwarf shrubs and grasses. Not only are these bush clumps a consequence of localized seed dispersal by birds, but they also help to promote, by providing perches for birds, the spread of the introduced Australian *Acacia cyclops* whose seeds also are dispersed by birds (Glyphis *et al.*, 1981). Prominent among the essentially frugivorous birds of the Strandveld are the Cape bulbul and the colies, especially *Colius indicus*.

CONCLUSIONS

This report was written in response to a request for information on the ecological importance, or otherwise, of birds, which could be useful in developing a strategy for more effective conservation of coastal lowland indigenous vegetation in the south-western Cape. I chose to base the report on a preliminary and provisional trophic classification of the avifaunas and their energy requirements in fynbos communities (at the alpha-diversity level), because, in the absence of detailed information on individual species, this should provide at least some initial insight into the ecological rôles that

the birds play in these ecosystems. Allied to this, I have included botanical information where necessary to reinforce assumptions I make about the importance of nectarivorous and frugivorous birds in ecological processes affecting the functioning of fynbos ecosystems.

In my deliberately broad approach, involving comparisons between the avifaunas of the major fynbos vegetation types, I have forfeited many details which probably would have emerged had I analysed data for variations in trophic structure within community types, as well as between types. In this context, Wiens (1981) has shown that caution and scepticism are in order when viewing the results of broad comparative analyses of avifaunal communities, based on single-year surveys over a variety of sites. According to Wiens (*op cit.*): "Rather consistently, ecological patterns are discerned on broad geographic or temporal scales of resolution, but when one looks to the dynamics of local populations and species assemblages for mechanisms to explain them, the patterns are missing, swamped by local variability." This more likely than not applies especially to bird communities in fynbos ecosystems which generally are characterized by high levels of ecological heterogeneity, on relatively small spatial, and short temporal, scales. I have also not considered a number of potentially important matters, such as the rôle of birds as predators on the seeds of plants and, hence, the way that this might affect the composition of seral communities of fynbos vegetation. Such apparent neglect, in most cases, simply reflects the absence of any worthwhile information, but it also indicates the current lack of a sound conceptual base necessary for beginning an understanding of the factors responsible for the high level of heterogeneity in the organization of fynbos ecosystems.

In spite of these caveats, two major conclusions are contained in this paper which should improve our current understanding of ecological functioning of fynbos ecosystems and, hence, influence current developments for more effective conservation of these ecosystems. First, it seems likely that birds are not major participants in energy or nutrient transfers in fynbos and, thus, energy fluxes and nutrient cycles in these ecosystems are largely the products of ecological interactions between members of other taxa that form part of the structure of the ecosystems. Secondly, birds appear to be important pollinators in fynbos ecosystems. These two conclusions are amplified below.

Because information on primary productivity, and the diets of birds, and on the abundance of their food resources, is either imperfect or lacking all together, it is not yet possible to assess properly the rôles of birds in trophic energy fluxes and mineral element cycles in fynbos ecosystems. However, the estimated annual energy requirements of these bird populations are relatively low. Although this could be taken to mean that much greater amounts

of energy and materials pass through other groups of consumers in fynbos communities, it does not mean that birds exert few, if any, significant effects on the functioning of fynbos ecosystems. Indeed, the observations now available indicate the potential importance of birds, through their patterns of food consumption, either as pollinators, especially in Coastal and Mountain Fynbos, or as seed-dispersers, especially in Strandveld vegetation.

The information available is too meagre to permit a definitive, quantitative assessment of the incidence of bird-pollinated plants in Coastal Fynbos vegetation. However, the data reported in this paper, and casual observations in the field, indicate that at least some Coastal Fynbos communities are rich in plant species which are characterized by the "syndrome of ornithophily". These kinds of plants produce relatively low concentrations of nectar and also have visual or morphological floral features typically facilitating avian pollination (Faegri and Pijl, 1979). Although virtually nothing is known about the interactions between ornithophilous plants and their pollinators in fynbos, it is probably reasonable to assume that a dynamic complex of mutual relationships between birds and plants has evolved in response to co-evolutionary selection. Thus, pollination by birds might affect inter-specific differences in phenology, dispersion and perhaps speciation in Coastal Fynbos plants. This is a subject which merits research.

The integral functioning of untransformed ecosystems encompassing remnant communities of Coastal Fynbos is threatened increasingly by fragmentation and insularization. This already has resulted in the endangerment or extinction of numerous plant species (Hall *et al.*, 1980). As immigration and visitation rates of avian pollinators to these islands of vegetation decrease, as they probably will under conditions of shrinking resources for birds, extinction of plant species must increase and could result in a drastic decline in the Coastal Fynbos flora.

Insularization of Strandveld vegetation is not nearly as far advanced as it is in the case of Coastal Fynbos, and especially Coastal Renosterveld which has been fragmented and reduced to less than 10 % of its former extent by the development of wheatlands (Bigalke, 1979). Moreover, Strandveld generally embraces less dynamic heterogeneity, in the form of successional or other patchiness of avian habitats, than Coastal Fynbos. Thus, while there is a need for a better understanding of the ecological rôles of birds, especially nectarivorous and frugivorous species, in maintaining Strandveld communities, the knowledge is required seemingly less urgently than for Coastal Fynbos and Renosterveld.

A final caveat, however, is based on a current paucity of information concerning a suspected dependence of populations of nectarivorous and, to a lesser extent, frugivorous birds on seasonal occupancy of different vegetation types and, hence, the interdependence of plant communities in these

vegetation types. In short, while it is known that, for instance, populations of the lesser doublecollared sunbird move from one plant community to another within one vegetation type, it is suspected that they might also move between two or more vegetation types. If this is indeed the case, then, a priority prerequisite for an effective conservation strategy for any of the three major types of coastal lowland, indigenous vegetation must be an holistic view of the interdependent functioning of the vegetation types in the south-western Cape.

Clearly, there is a case for urgent research aimed at yielding the knowledge and precepts required for optimization of the dispersion, design and management of nature reserves intended to conserve fynbos communities. Studies of the interrelations of ornithophilous plants and their pollinators should constitute a prominent part of this research for it is crucial to know the spatial and temporal scales of fynbos habitats, including various successional seres and their arrangement, which will ensure the continuing existence of populations of avian pollinators and thereby the populations of plants dependent on these pollinators.

ACKNOWLEDGEMENTS

Thanks are due to R. K. Brooke, R. A. C. Jensen, S. J. Milton, J. C. Sinclair, J. Sommerville and G. D. Underhill for assistance in the field. T. M. and A. Crowe and S. R. Williamson helped with the processing of data. F. J. Kruger and C. Boucher advised in the initial selection of study sites. P. G. H. Frost and A. V. Hall gave helpful advice. The Department of Water Affairs, Forestry and Environmental Conservation, and the Divisional Council of the Cape, allowed access to study sites in areas under their jurisdiction. The South African Council for Scientific and Industrial Research, through its Fynbos Biome Project, and the University of Cape Town provided financial support.

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APPENDIX 1
Plant and bird community study sites and characteristics in the south-western Cape fynbos biome

Site	Co-ordinates	Altitude (m)	Aspect	Slope	Annual ^a rainfall (mm)	Geology	Area (ha)	Vegetation	
								Age (yr)	Type
Melkbosch ...	S 33° 45', E 18° 27'	0-15	W E	0-8°	570	White-grey sandy soil	50	> 15	Strandveld
Geelbek	S 33° 12', E 18° 08'	0-15	W	0-8°	320	Langebaan limestone	50	> 15	Strandveld
De Grendel ..	S 33° 51', E 18° 35'	300	W SW	9-26°	450	Malmesbury slates, Tygerberg formation	50	> 15	Coastal Renosterveld
Barhuis	S 33° 14', E 18° 15'	100	W NW	0-2°	470	White to light red sand	50	—	Coastal Fynbos
Swartboschkloof	S 34° 00', E 18° 57'	300	S SE	9-45°	1 470	Cape granite coarse grained	50	20	Mountain Fynbos
Sir Lowry's Pass	S 34° 09', E 18° 50'	600	N E	0-26°	No data	TMS Peninsula formation	50	5	Mountain Fynbos
Silvermine ...	S 34° 05', E 18° 25'	1 000	NW	0-10°	1 300	TMS Peninsula formation	50	21	Mountain Fynbos
Lebanon 1 ...	S 34° 12', E 19° 08'	700	SW	0-18°	950	TMS Peninsula formation	50	21	Mountain Fynbos
Lebanon 2 ...	—	900	SW	15-25°	—	—	5	5	
Lebanon 3 ...	—	950	SW	30-35°	—	—	40	10	
Lebanon 4 ...	—	1 000	SE	0-35°	—	—	5	10	

^a All 25 year means, except Lebanon (4 yr) and Silvermine (3 yr).

APPENDIX 2

Mass (g live wht) and diet classes for avian species.

1 = raptor, 2 = granivore, 3 = folivore, 4 = insectivore, 5 = scavenger,
6 = frugivore, 7 = nectarivore.

Species	Mass	Diet class
<i>Falco biarmicus</i>	587	1
<i>Falco tinnunculus</i>	130	1
<i>Elanus caeruleus</i>	192	1
<i>Circus maurus</i>	658	1
<i>Francolinus africanus</i>	405	2
<i>Francolinus capensis</i>	750	2
<i>Coturnix coturnix</i>	78	2
<i>Turnix hottentotta</i>	52	2
<i>Columba guinea</i>	350	2
<i>Streptopelia capicola</i>	150	2
<i>Stigmatopelia senegalensis</i>	85	2
<i>Oena capensis</i>	42	2
<i>Colius striatus</i>	52	3
<i>Colius colius</i>	42	3
<i>Colius indicus</i>	58	6
<i>Tricholaema leucomelas</i>	35	4
<i>Geocolaptes olivaceus</i>	170	4
<i>Certhilauda albescent</i>	27	4
<i>Mirafra apiata</i>	29	4
<i>Certhilauda curvirostris</i>	24	4
<i>Eremopterix verticalis</i>	17	4
<i>Corvus albus</i>	700	5
<i>Parus afer</i>	20	4
<i>Anthoscopus minutus</i>	7	4
<i>Chaetops frenatus</i>	41	4
<i>Pycnonotus capensis</i>	40	6
<i>Monticola rupestris</i>	80	4
<i>Monticola explorator</i>	37	4
<i>Cercomela familiaris</i>	21	4
<i>Saxicola torquata</i>	15	4
<i>Cossypha caffra</i>	27	4
<i>Erythropygia coryphaeus</i>	21	4
<i>Bradypterus victorini</i>	10	4
<i>Sphenoeacus afer</i>	31	4
<i>Malcorus pectoralis</i>	11	4
<i>Sylvietta rufescens</i>	11	4
<i>Apalis thoracica</i>	10	4
<i>Cisticola fulvicapilla</i>	9	4
<i>Cisticola subruficapilla</i>	9	4
<i>Prinia maculosa</i>	10	4
<i>Parisoma subcaeruleum</i>	14	4
<i>Parisoma layardi</i>	14	4

Species	Mass	Diet class
<i>Bradornis infuscatus</i>	27	4
<i>Siegelus silens</i>	26	4
<i>Batis capensis</i>	12	4
<i>Lanius collaris</i>	41	4
<i>Laniarius ferrugineus</i>	55	4
<i>Telophorus zeylonus</i>	65	4
<i>Creatophora cinerea</i>	70	4
<i>Spreo bicolor</i>	102	4
<i>Promerops cafer</i>	33	7
<i>Nectarinia famosa</i>	17	7
<i>Nectarinia violacea</i>	10	7
<i>Nectarinia chalybea</i>	9	7
<i>Zosterops pallidus</i>	11	4
<i>Passer melanurus</i>	27	2
<i>Ploceus capensis</i>	45	2
<i>Euplectes orix</i>	24	2
<i>Euplectes capensis</i>	20	2
<i>Serinus totta</i>	30	2
<i>Serinus canicollis</i>	15	2
<i>Serinus alario</i>	12	2
<i>Serinus sulphurata</i>	29	2
<i>Serinus albogularis</i>	26	2
<i>Serinus flaviventris</i>	17	2
<i>Serinus leucoptera</i>	24	2
<i>Fringillaria capensis</i>	21	2

APPENDIX 3

List of plant species, fruit and flower types, at study sites in fynbos vegetation in the south-western Cape.

Fruit type: 1 = fleshy with single seed, 2 = fleshy with numerous seeds, 3 = dry, including pods, nuts, achenes and capsules.

Fruit size: 1 = <3 mm, 2 = 3–10 mm, 3 = >10 mm.

Fruit colour: 1 = white yellow, 2 = orange red, 3 = purple black, 4 = brown green.

Flower size: 1 = <3 mm, 2 = 3–10 mm, 3 = >10 mm.

Flower colour: 1 = brown green, 2 = white yellow, 3 = orange red pink, 4 = blue lilac.

Study sites: 1 = Geelbek, 2 = De Grendel, 3 = Melkbosch, 4 = Swartboschkloof, 5 = Sir Lowry's Pass, 6 = Barhuis, 7 = pre-fire Silvermine, 8 = Lebanon 1, 9 = Lebanon 2, 10 = Lebanon 3, 11 = Lebanon 4, 12 = post-fire Silvermine.

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Adenandra villosa</i>	3	1	4	2	2	5, 12
<i>Agapanthus africanus</i> ...	3	2	3	3	4	4
<i>Agathelpis dubia</i>	3	1	4	1	1	12
<i>Agathosma bifida</i>	3	1	4	1	2	9, 10, 11
<i>A. imbricata</i>	3	1	4	1	2	1
<i>Agyrolobium</i> sp.	3	1	4	2	2	3
<i>Albuca</i> sp.	3	2	4	2	2	1
<i>A. cooperi</i>	3	1	4	2	2	12
<i>Amphibolia indecora</i> ...	3	1	4	2	3	1, 3
<i>Amphithalea</i> sp.	3	1	4	2	3	5
<i>Anagallis arvensis</i>	3	1	4	2	2	1
<i>Anaxeton asperum</i>	3	1	4	1	2	5
<i>Anemone capensis</i>	3	2	4	2	2	10
<i>Anthospermum</i>						
<i>aethiopicum</i>	3	1	4	1	1	1, 2, 3
<i>A. bergianum</i>	3	1	4	1	1	5
<i>A. ciliare</i>	3	1	4	1	1	2
<i>A. prostratum</i>	3	1	4	1	1	8, 9, 10
<i>Antizoma capensis</i>	1	2	2	1	2	1, 2, 3
<i>Arctopus echinatus</i>	3	1	4	2	2	2
<i>Arctotis acaulis</i>	3	1	4	2	3	2
<i>A. breviscarpa</i>	3	2	4	3	3	1
<i>Aristea africana</i>	3	2	4	2	4	12
<i>A. macrocarpa</i>	3	2	4	2	4	12
<i>A. racemosa</i>	3	2	4	2	4	9
<i>A. spiralis</i>	3	1	4	2	4	8, 9, 10, 11
<i>Aspalathus</i> sp.	3	2	4	2	2	7, 12
<i>A. carnosus</i>	3	1	4	2	2	5
<i>A. ciliaris</i>	3	1	4	2	2	2, 5
<i>A. ericaefolius</i>	3	1	4	2	2	2
<i>A. hispida</i>	3	1	4	1	2	3
<i>A. millefolia</i>	3	2	4	2	2	10

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Aspalathus retroflexus</i> . . .	3	2	4	2	2	12
<i>Asparagus capensis</i>	2	2	2	1	2	1, 2, 3, 6
<i>A. compactus</i>	2	2	2	1	2	2
<i>A. crispus</i>	2	2	1	1	2	1, 2, 3
<i>A. stipulaceus</i>	2	2	—	1	2	1, 3
<i>A. thunbergianus</i>	2	2	2	1	2	2, 4
<i>Athrixia crinita</i>	3	1	4	2	2	2
<i>Babiana ambigua</i>	3	1	4	3	4	1, 3
<i>B. plicata</i>	3	1	4	3	4	2
<i>B. tubulosa</i>	3	1	4	3	3	3
<i>Berkheya armata</i>	3	1	4	3	2	2
<i>B. herbacea</i>	3	1	4	2	2	4
<i>B. ilicifolia</i>	3	1	4	3	2	5
<i>Berzelia abrotanoides</i> . . .	3	1	4	1	2	8, 9, 10, 11
<i>Blaeria dumosa</i>	3	1	4	1	3	4, 8, 9, 10, 11
<i>B. ericoides</i>	3	1	4	1	3	5
<i>Bobartia</i> sp.	3	2	4	3	2	3
<i>B. indica</i>	3	2	4	3	2	4, 5
<i>Brunia alopecuroides</i> . . .	3	1	4	1	2	10
<i>B. nodiflora</i>	3	2	4	1	2	4, 9, 10
<i>Bulbine alooides</i>	3	1	4	2	2	2
<i>Bulbinella triquetra</i>	3	1	4	2	2	2
<i>Cannamois acuminata</i> . . .	3	1	4	1	1	6
<i>C. virgata</i>	3	2	4	1	1	4
<i>Carpacoe spermacoea</i> . . .	3	2	4	2	1	10
<i>C. vaginellata</i>	3	2	4	2	1	9, 10
<i>Carpobrotus</i> sp.	2	3	4	3	2	5
<i>Cassytha ciliolata</i>	1	2	1	1	2	4
<i>Centella virgata</i>	3	1	4	1	1	5
<i>Cephalophyllum dubium</i> . .	3	1	4	3	2	3
<i>Chironia baccifera</i>	2	2	2	2	3	2
<i>Chondropetalum</i> <i>deustum</i>	3	2	4	1	1	8, 9, 10, 11
<i>C. hookerianum</i>	3	1	4	1	1	5, 8
<i>Chrysanthemoides</i> <i>incana</i>	1	2	3	2	2	1, 3
<i>C. monilifera</i>	1	2	3	2	2	12
<i>Chrysithrix capensis</i> . . .	3	1	4	1	1	9, 10, 11
<i>C. junciformis</i>	3	1	4	1	1	8
<i>Cineraria geifolia</i>	3	1	4	2	2	3
<i>Cliffortia cuneata</i>	3	1	4	1	1	4
<i>C. graminea</i>	3	1	4	1	1	10, 11
<i>C. ruscifolia</i>	3	1	4	1	1	4
<i>C. subsetacea</i>	3	1	4	1	1	5
<i>Clutia alaternoides</i>	3	1	4	1	2	4, 5

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Clutia daphnoides</i>	3	2	4	1	2	1, 3, 6
<i>C. polygonoides</i>	3	1	4	1	2	2, 9, 10
<i>Coleonema juniperinum</i> ..	3	1	4	1	2	4
<i>Colpoön compressum</i> ..	1	3	3	1	2	1, 3
<i>Commelina</i> sp.	3	1	4	2	2	3
<i>Compositae</i> sp. a	3	1	4	—	—	5
<i>Compositae</i> sp. b	3	1	4	2	—	1
<i>Corymbium africanum</i> ..	3	1	4	2	2	5
<i>C. congestum</i>	3	2	4	1	2	10, 11
<i>C. enerve</i>	3	1	4	2	2	5
<i>C. glabrum</i>	3	1	4	2	3	2, 4, 5, 8, 9, 10
<i>Cotula turbinata</i>	3	1	4	2	2	1
<i>Cotyledon orbiculare</i> ...	3	1	4	3	3	1, 3
<i>C. paniculata</i>	3	1	4	3	3	1, 3
<i>Crassula capensis</i>	3	1	4	2	2	2
<i>C. cymosa</i>	3	1	4	1	2	1
<i>C. fulva</i>	3	1	4	2	2	5
<i>C. muscosa</i>	3	1	4	1	2	1
<i>C. zeyheriana</i>	3	1	4	1	2	1
<i>Cymbopogon marginatus</i>	3	1	4	1	1	4
<i>Cyphia crenata</i>	3	1	4	2	2	3
<i>C. phytiuma</i>	3	1	4	2	2	2
<i>C. volubilis</i>	3	1	4	2	2	1
<i>Diascia unilabiata</i>	3	1	4	2	4	1
<i>Dilatriis corymbosa</i>	3	1	4	2	4	5, 7, 12
<i>Diosma hirsuta</i>	3	1	4	1	2	4, 5
<i>D. oppositifolia</i>	3	1	4	1	2	5
<i>Diospyros glabra</i>	1	2	3	1	2	4
<i>Disperis capensis</i>	3	1	4	3	4	5
<i>Drosanthemum</i>						
<i>calycinum</i>	3	1	4	2	—	2
<i>Drosera aliciae</i>	3	1	4	2	3	9, 10, 11
<i>D. hilaris</i>	3	1	4	2	3	8, 9, 10, 11
<i>D. trinerva</i>	3	1	4	2	2	5
<i>Ehrharta calycina</i>	3	1	4	1	1	1, 3, 6
<i>E. dodii</i>	3	1	4	1	1	9
<i>E. erecta</i>	3	1	4	1	1	1
<i>E. ramosa</i>	3	1	4	1	1	1, 9, 10, 11
<i>E. villosa</i>	3	1	4	1	1	6
<i>Elegia</i> sp.	3	1	4	1	1	7
<i>E. asperifolia</i>	3	1	4	1	1	10, 11
<i>E. juncea</i>	3	1	4	1	1	5, 9, 10
<i>E. parviflora</i>	3	1	4	1	1	5
<i>E. racemosa</i>	3	1	4	1	1	4, 5, 8, 9, 10, 11

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Elegia spathacea</i>	3	1	4	1	1	5
<i>E. stipularis</i>	3	2	4	1	1	7
<i>E. vaginulata</i>	3	2	4	1	1	9
<i>Elytropappus</i> sp.	3	1	4	1	1	6
<i>E. rhinocerotis</i>	3	1	4	1	1	2
<i>Epischoenus</i>						
<i>quadrangularis</i>	3	1	4	1	1	8, 10, 11
<i>Eragrostis</i> sp.	3	1	4	1	1	2
<i>Eremia totta</i>	3	1	4	1	2	4
<i>Erepsia pageae</i>	3	1	4	2	3	2
<i>Erica articularis</i>	3	1	4	1	2	4, 5
<i>E. calycina</i>	3	1	4	1	2	11
<i>E. calystegia</i>	—	—	—	—	—	5
<i>E. cerinthoides</i>	3	1	4	3	3	5
<i>E. coccinea</i>	3	1	4	3	3	5, 11
<i>E. corifolia</i>	3	1	4	1	3	5
<i>E. hispidula</i>	3	1	4	1	3	4, 8, 9, 10, 11
<i>E. imbricata</i>	3	1	4	1	2	4, 5
<i>E. longifolia</i>	3	1	4	3	3	5, 9, 10
<i>E. lutea</i>	3	1	4	1	2	5, 11
<i>E. massonii</i>	3	1	4	2	3	5
<i>E. plukenetii</i>	3	1	4	3	3	4, 5, 9, 10
<i>E. pulchella</i>	3	1	4	1	3	5, 7
<i>E. sessiliflora</i>	3	1	4	2	1	8, 9, 10
<i>E. sphaeroidea</i>	3	1	4	—	—	4
<i>E. transparens</i>	3	1	4	1	3	11
<i>Eriocephalus africana</i> ...	3	1	4	1	1	2
<i>E. racemosa</i>	3	1	4	1	4	1, 3
<i>Eriospermum cernuum</i> ..	3	1	4	2	2	12
<i>Eroeda imbricata</i>	3	1	4	2	2	5
<i>Eroedium</i> sp.	3	1	4	1	3	5
<i>Euclea racemosa</i>	1	2	3	1	2	1, 3
<i>Euphorbia burmanii</i>	3	1	4	1	2	1, 3
<i>E. caput-medusae</i>	3	1	4	2	3	1, 3
<i>E. mauritanica</i>	3	1	4	2	2	1, 3
<i>Fagelia bituminosa</i>	3	2	4	2	2	12
<i>Felicia fruticosa</i>	3	1	4	2	4	2
<i>F. tenella</i>	3	1	4	2	4	1
<i>Ficinia bracteata</i>	3	1	4	1	1	4
<i>F. bulbosa</i>	3	1	4	1	1	12
<i>F. capillaris</i>	3	1	4	1	1	4
<i>F. composita</i>	3	1	4	1	1	5
<i>F. deusta</i>	3	1	4	1	1	4, 5, 12
<i>F. dunensis</i>	3	1	4	1	1	1, 3, 6
<i>F. filiformis</i>	3	1	4	1	1	5, 7, 12

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Ficinia lithosperma</i>	3	1	4	1	1	12
<i>F. pinguor</i>	3	1	4	1	1	12
<i>F. tenuifolia</i>	3	1	4	1	1	7
<i>F. zeyheri</i>	3	1	4	1	1	9, 10, 11
<i>Galium tomentosum</i>	3	1	4	1	1	1, 3
<i>Geissorhiza imbricata</i>	3	1	4	2	2	1
<i>Geophyte</i> sp. a	—	—	—	—	—	1
<i>Geophyte</i> sp. b	—	—	—	—	—	1
<i>Geophyte</i> sp. c	—	—	—	—	—	2
<i>Geophyte</i> sp. d	—	—	—	—	—	2
<i>Gerbera asplenifolia</i>	3	1	4	2	2	5
<i>Gnidia humilis</i>	3	1	4	1	2	2
<i>G. pinifolia</i>	3	1	4	2	2	7
<i>Grubbia tomentosa</i>	2	2	3	1	1	8, 9, 10
<i>Haemanthus</i> sp.	1	3	2	3	3	2
<i>Hebenstreitia dentata</i>	3	1	4	1	2	1
<i>H. repens</i>	3	1	4	1	2	1
<i>Helichrysum</i> sp.	3	1	4	—	—	1
<i>H. crassifolium</i>	3	1	4	1	2	2
<i>H. cymosum</i>	3	1	4	1	2	2
<i>H. felinum</i>	3	1	4	2	2	10
<i>H. indicum</i>	3	1	4	—	—	4
<i>H. revolutum</i>	3	1	4	3	2	1, 2, 3
<i>H. sesamoides</i>	3	1	4	2	2	5, 7
<i>H. teretifolium</i>	3	1	4	1	2	1, 2
<i>H. vestitum</i>	3	1	4	3	2	5, 7, 12
<i>Helictotrichon capense</i>	3	1	4	1	1	2
<i>Heliphila scoparia</i>	3	1	4	2	3	5
<i>Helipterum canescens</i>	3	1	4	2	3	5
<i>Hemimeris sabulosa</i>	3	1	4	2	2	1
<i>Herb</i> sp. a	—	—	—	—	—	3
<i>Herb</i> sp. b	—	—	—	—	—	2
<i>Herb</i> sp. c	—	—	—	—	—	2
<i>Hermannia trifoliata</i>	3	1	4	2	3	1, 3
<i>Hermas quinquedentata</i>	3	2	4	1	2	5
<i>H. villosa</i>	3	2	4	1	2	5
<i>Hippia pilosa</i>	3	1	4	2	2	9, 11
<i>Hypodiscus</i>						
<i>albo-aristatus</i>	3	1	4	1	1	4, 5, 8, 9, 10, 11
<i>H. aristatus</i>	3	1	4	1	1	4, 5, 7, 8, 12
<i>H. willdenowia</i>	3	2	4	1	1	6, 12
<i>Ifloga reflexa</i>	3	1	4	1	2	2
<i>Indigofera heterophylla</i>	3	1	4	1	3	1, 2, 3
<i>I. procumbens</i>		1	4	2	3	1
<i>Klattia partita</i>	3	2	4	2	2	10, 11

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Knowltonia hirsuta</i>	1	2	3	2	2	2
<i>Lachnaea capitata</i>	3	1	4	2	2	6
<i>Lachnospermum umbellatum</i>	3	1	4	2	2	9
<i>Lampranthus promontorii</i>	3	1	4	2	2	12
<i>Leptocarpus</i> sp.	3	2	4	1	1	11
<i>L. membranaceus</i>	3	1	4	1	2	5, 8, 9, 10
<i>Leucadendron laurum</i>	3	2	4	2	2	7, 12
<i>L. salignum</i>	3	2	3	3	2	5, 6, 7
<i>L. sessile</i>	3	2	3	3	2	5
<i>L. spissifolium</i>	3	2	3	3	2	4, 9, 10, 11
<i>L. xanthoconus</i>	3	2	4	3	1	8, 9, 10
<i>Leucospermum conocarpodendron</i>	3	2	1	2	2	5, 11
<i>L. oleaefolium</i>	3	2	1	3	2	5
<i>L. tomentosum</i>	3	2	4	3	2	6
<i>Leyssera gnaphaloides</i>	3	1	4	2	2	1
<i>Lichtensteinia lacera</i>	3	2	4	1	2	4
<i>Limonium roseum</i>	3	1	4	2	3	1, 3
<i>Lobelia</i> sp.	3	1	4	2	4	7
<i>L. comosa</i>	3	1	4	2	4	5
<i>L. coronopifolia</i>	3	1	4	2	4	4, 5, 12
<i>L. pinifolia</i>	3	1	4	2	4	5
<i>Lobostemon hispidus</i>	3	1	4	2	4	2
<i>Lotononis prostrata</i>	3	1	4	2	2	2
<i>Lycium afrum</i>	1	2	3	2	4	2
<i>Maytenus heterophylla</i>	1	1	1	2	2	1
<i>M. maritimus</i>	1	2	1	1	2	1
<i>M. oleoides</i>	1	2	1	1	2	4
<i>Melandrium undulatum</i>	3	1	4	2	2	2
<i>Merxmeullera lanata</i>	3	1	4	1	1	12
<i>M. rufa</i>	3	1	4	1	1	8, 9, 10
<i>M. stricta</i>	3	1	4	1	1	9
<i>Metalasia cephalotes</i>	3	1	4	1	2	4, 5, 12
<i>M. muricata</i>	3	1	4	1	2	4, 5
<i>Metzleria humifusa</i>	3	1	4	1	3	5
<i>Microloma</i> sp.	3	1	4	1	3	1, 3
<i>M. sagittatum</i>	3	1	4	1	3	1, 3
<i>Microstylis villosa</i>	3	1	4	1	2	7, 12
<i>Mimetes cucullatus</i>	3	2	4	3	3	8, 9, 10
<i>Mohria caffrorum</i>	—	—	—	—	—	2
<i>Monochlamys</i> sp.	1	2	1	1	1	1
<i>M. albicans</i>	1	2	1	1	1	2
<i>Montinia caryophyllacea</i>	3	2	4	1	2	4
<i>Muraltia alba</i>	3	1	4	1	2	4

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Muraltia dumosa</i>	3	1	4	1	4	1
<i>Myrica kraussinia</i>	1	2	3	1	1	9, 11
<i>Nebelia fragiraioides</i>	3	1	4	1	2	8
<i>N. paleacea</i>	3	1	4	1	2	5, 9, 10, 11
<i>Nemesia parviflora</i>	3	1	1	2	4	1
<i>Nylandtia spinosa</i>	1	2	2	1	4	3, 6
<i>Olea exasperata</i>	1	2	3	1	2	1, 3
<i>Osmitopsis afra</i>	3	1	4	2	2	9, 10, 11
<i>O. parviflora</i>	3	1	4	2	2	5
<i>Osteospermum</i>						
<i>clandestinum</i>	3	1	4	2	2	2
<i>O. junceum</i>	3	2	4	2	2	9
<i>O. spinosum</i>	3	2	4	2	2	2
<i>Othonna coronopifolia</i> ..	3	1	4	2	2	3
<i>O. cylindrica</i>	3	1	4	2	2	1
<i>O. filicaulis</i>	3	1	4	1	4	1, 3
<i>O. quinquedentata</i>	3	1	4	2	2	5, 9
<i>Oxalis</i> sp. a	3	1	4	2	2	3
<i>Oxalis</i> sp. b	3	1	4	2	—	1
<i>Oxalis</i> sp. c	3	1	4	—	—	4
<i>Oxalis</i> sp. d	3	1	4	2	2	2
<i>Oxalis</i> sp. e	3	1	4	—	—	6
<i>O. eckloniana</i>	3	1	4	2	3	2
<i>O. hirta</i>	3	1	4	2	3	2
<i>O. pes-caprae</i>	3	1	4	2	2	2
<i>Passerina paludosa</i>	3	1	4	1	1	12
<i>P. vulgaris</i>	3	1	4	1	1	3, 6
<i>Pelargonium</i>						
<i>alchemilloides</i>	3	1	4	2	2	2
<i>P. angulosum</i>	3	1	4	2	3	12
<i>P. gibbosum</i>	3	1	4	2	2	1, 3
<i>P. labotum</i>	3	1	4	2	1	2
<i>P. myrrhifolium</i>	3	1	4	2	3	4
<i>P. saniculaefolium</i>	3	1	4	2	3	4
<i>P. triste</i>	3	1	4	2	1	2
<i>Pendaea mucronata</i>	3	1	4	1	1	4, 5, 7, 9, 10, 11, 12
<i>Pentaschistis</i> sp. a	3	1	4	1	1	5
<i>Pentaschistis</i> sp. b	3	1	4	1	1	4, 7
<i>P. aristidioides</i>	3	1	4	1	1	12
<i>P. colorata</i>	3	1	4	1	1	4, 8, 9, 10, 11
<i>P. curvifolia</i>	3	1	4	1	1	4
<i>P. palescens</i>	3	1	4	1	1	4, 5
<i>P. tortuosa</i>	3	1	4	1	1	12
<i>Petalacte</i> sp.	3	1	4	1	2	12

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Peucedanum ferulaceum</i>	3	2	4	1	1	9, 10
<i>P. sieberianum</i>	3	2	4	1	2	5
<i>Phaenocoma prolifera</i>	3	1	4	2	3	5
<i>Pharnaceum lanatum</i>	3	1	4	1	1	3, 6
<i>Phillipia leeana</i>	3	1	4	1	1	5
<i>Phyllica cephalantha</i>	3	1	4	1	2	6
<i>P. ericoides</i>	3	1	4	1	2	3
<i>P. gracilis</i>	3	1	4	1	2	4, 8, 9
<i>P. parviflora</i>	3	1	4	1	2	5
<i>P. stipularis</i>	3	1	4	1	2	6
<i>Pinus pinaster</i>	3	2	4	1	1	4
<i>Polyarrhena reflexa</i>	3	1	4	2	2	9
<i>Polycarena cephalophora</i>	3	1	4	2	4	1
<i>Polygala bracteolata</i>	3	1	4	2	4	12
<i>P. myrtiflora</i>	3	1	4	2	4	1
<i>Polygonum undulatum</i>	3	2	4	1	2	2, 5
<i>Priestleya vestita</i>	3	1	4	2	2	5
<i>Printzia aromatica</i>	3	1	4	2	3	2
<i>Prismatocarpus fruticosus</i>	3	1	4	1	2	4
<i>Protea acaulis</i>	3	2	4	3	3	4, 5
<i>P. cynaroides</i>	3	2	4	3	3	5, 8, 9, 10, 11
<i>P. neriifolia</i>	3	2	4	3	3	4, 5, 9
<i>P. nitida</i>	3	2	4	3	2	4
<i>P. repens</i>	3	2	4	3	3	4
<i>P. scabra</i>	3	2	4	3	1	8, 9
<i>P. speciosa</i>	3	2	4	3	3	9, 11
<i>Pseudopentameris</i>						
<i>macrantha</i>	3	1	4	1	1	8, 11
<i>Psoralea aphylla</i>	3	2	4	2	4	9, 10
<i>Pterocelastrus</i>						
<i>tricuspidatus</i>	1	1	2	1	2	1, 3
<i>Putterlickia pyracantha</i>	1	2	2	1	2	1, 2, 3
<i>Rafnia perfoliata</i>	3	1	4	2	2	5
Restiads						8
<i>Restio</i> sp.	3	2	4	1	1	11
<i>R. ambiguus</i>	3	1	4	1	1	8, 10, 11
<i>R. cuspidata</i>	3	1	4	1	1	4, 5, 12
<i>R. dispar</i>	3	1	4	1	1	8, 9, 10, 11
<i>R. egregius</i>	3	1	4	1	1	5, 8, 10
<i>R. eleocharis</i>	3	1	4	1	1	3
<i>R. filiformis</i>	3	1	4	1	1	4, 5
<i>R. gaudichaudianus</i>	3	1	4	1	1	4
<i>R. monanthus</i>	3	1	4	1	1	6
<i>R. perplexus</i>	3	1	4	1	1	8, 10
<i>R. purpurascens</i>	3	1	4	1	1	10

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Restio tenuissimus</i>	3	1	4	1	1	5, 7, 12
<i>R. triteus</i>	3	1	4	1	1	4, 5, 7, 8, 9, 10
<i>Rhus angustifolia</i>	1	2	1	1	2	2, 4
<i>R. glauca</i>	1	2	2	1	2	1, 3
<i>R. incana</i>	1	2	2	1	2	2, 3
<i>R. mucronata</i>	1	2	2	1	2	1, 3
<i>R. rosmarinifolia</i>	1	2	1	1	2	4
<i>Roella ciliaris</i>	3	1	4	2	4	5, 12
<i>Ruschia carolii</i>	3	1	4	2	4	3
<i>Salsola australis</i>	3	1	4	1	1	1
<i>Salteria sarcocolla</i>	3	1	4	2	3	5
<i>Salvia africana</i>	3	1	4	2	4	2
<i>S. aurea</i>	3	1	4	3	3	1, 2, 3
<i>Schizaea pectinata</i>	—	—	—	—	—	8, 9, 10, 11, 12
<i>Scyphogyne muscosa</i>	3	1	4	1	3	5, 12
<i>Selago spuria</i>	3	1	4	1	4	4, 12
<i>Senecio</i> sp.	3	1	4	—	—	5
<i>S. aloides</i>	3	1	4	—	—	1
<i>S. elegans</i>	3	1	4	2	4	1
<i>S. grandiflorus</i>	3	2	4	2	2	12
<i>S. lineatus</i>	3	1	4	2	2	2
<i>S. pinifolius</i>	3	1	4	2	2	2, 9
<i>S. purpureus</i>	3	1	4	2	4	5
<i>S. rigidus</i>	3	1	4	2	2	7, 9, 12
<i>S. umbellatus</i>	3	1	4	2	4	5, 9, 10, 11
<i>Serruria elongata</i>	3	1	4	2	3	5
<i>Sickmannia radiata</i>	3	2	4	2	2	12
<i>Solanum</i> sp.	2	2	—	2	—	3
<i>S. guineense</i>	2	2	3	2	4	1, 2, 3
<i>Spiloxene capensis</i>	3	1	4	2	2	2
<i>Staberoha cernua</i>	3	1	4	1	1	4, 5, 7, 8, 9, 10, 12
<i>S. distachya</i>	3	1	4	1	1	6
<i>Stachys aethiopicum</i>	3	1	4	2	2	1, 2
<i>Stilbe vestitum</i>	3	1	4	1	2	12
<i>Stoebe</i> sp.	3	1	4	1	1	12
<i>S. aethiopica</i>	3	1	4	1	2	5
<i>S. cinerea</i>	3	1	4	1	1	4, 9, 10
<i>S. incana</i>	3	1	4	1	1	7, 9, 10, 11
<i>S. spiralis</i>	3	1	4	1	2	5
<i>Struthiola hirsuta</i>	3	1	4	2	2	5
<i>S. linearis</i>	3	1	4	2	2	5
<i>S. myrsinites</i>	3	1	4	2	2	8
<i>Sutera hispida</i>	3	1	4	2	2	2

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Sympieza articulata</i>	3	1	4	1	2	8
<i>Synnotia villosa</i>	3	1	4	3	2	2
<i>Teloschistes capensis</i>	—	—	—	—	—	1
<i>Tetragonia fruticosa</i>	3	1	4	1	2	1, 2, 3
<i>T. spicata</i>	3	2	4	1	2	2
<i>Tetraria autumnalis</i>	3	1	4	1	1	4
<i>T. brevicaulis</i>	3	1	4	1	1	5, 8, 10, 11
<i>T. bromoides</i>	3	1	4	1	1	5, 8, 9, 10
<i>T. compacta</i>	3	1	4	1	1	5, 7
<i>T. compar</i>	3	1	4	1	1	12
<i>T. cuspidata</i>	3	1	4	1	1	4, 5
<i>T. exilis</i>	3	1	4	1	1	8, 9, 10, 11
<i>T. fasciata</i>	3	1	4	1	1	4, 9, 10
<i>T. fimbriolata</i>	3	1	4	1	1	8, 9, 10
<i>T. flexuosa</i>	3	1	4	1	1	5, 7, 8, 9, 10, 11, 12
<i>T. thermalis</i>	3	1	4	1	1	4, 5, 8, 11
<i>T. triangularis</i>	3	2	4	1	1	11
<i>T. ustulata</i>	3	1	4	1	1	4, 7
<i>Thamnochortus</i> <i>dichotomus</i>	3	1	4	1	1	4, 5
<i>T. fruticosus</i>	3	2	4	1	1	7, 12
<i>T. gracilis</i>	3	1	4	1	1	5, 8, 9, 10, 11
<i>T. obtusus</i>	3	1	4	1	1	6
<i>T. similis</i>	3	2	4	1	1	9
<i>T. spicigerus</i>	3	1	4	1	1	1, 3
<i>Themeda triandra</i>	3	1	4	1	1	4
<i>Thesium</i> sp.	3	1	4	1	1	11